PATENT ABSTRACTS OF JAPAN

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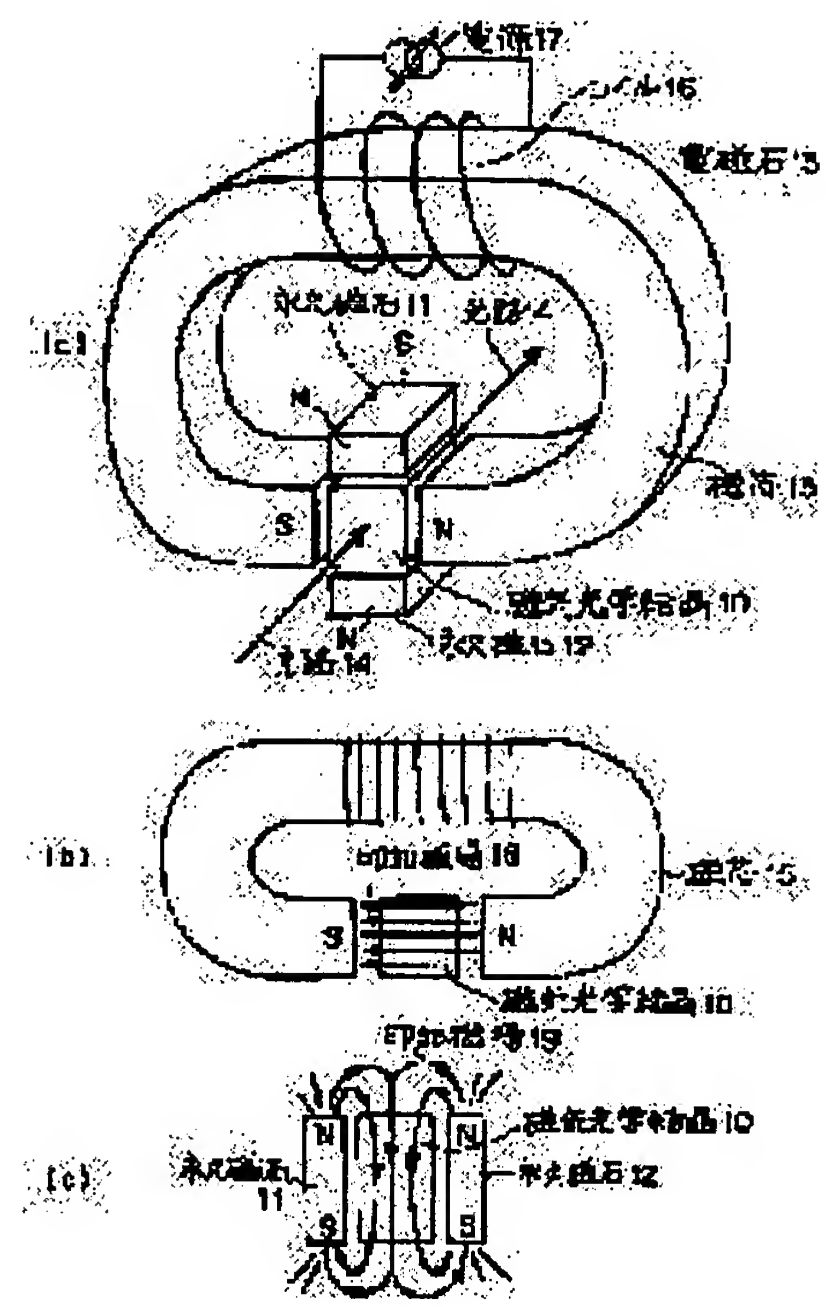
(54) FARADAY ROTATOR

(57)Abstract:

PROBLEM TO BE SOLVED: To provide a Faraday rotator with which the impression of a uniform magnetic field on a magnet optical crystal is possible and the size over the entire part of the device is suppressed.

SOLUTION: An electromagnet 13 impresses the magnetic field in a direction transverse to an optical path 14 on the magnet optical crystal 10. Permanent magnets 11, 12 are disposed on the surfaces which are the flanks facing the magneto-optical crystal 10 and are the surface not provided with a magnetic core 15 by unifying their polarities. The sections of both S and N poles of the magnetic core 5 are formed to nearly the same shape so as to cover the flanks of the magneto-optical crystal 10 to impart the uniform impression magnetic field 18 on the magneto-optical crystal 10. The permanent magnets 11, 12 are likewise disposed on the flanks of the magneto-optical crystal 10 and impress the uniform magnetic field 19 on the magneto-optical crystal 10. The electromagnet 13 and the permanent magnets 11, 12 may be disposed to avert the optical path 14 and since the permanent magnets 11, 12 in particular are smaller than the electromagnet 13, the size over the entire part of the Faraday rotator is not increased even if these magnets are disposed in two pieces.



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CLAIMS

[Claim(s)]
[Claim 1] The Faraday-rotation child with the Faraday-rotation angle of an incident light strange good characterized by providing the following. The magneto optics crystal which is transparent and has magnetism to the aforementioned incident light. The permanent magnet to which the magnetic field of the 1st direction which is parallel or intersects the travelling direction of the aforementioned incident light is impressed to the aforementioned magneto optics crystal, it is arranged so that the optical path of the aforementioned incident light may not be interrupted, and magnetic saturation of the aforementioned magneto optics crystal is carried out. The electromagnet magnetic field strength and whose direction it is arranged so that it is a perpendicular or the crossing direction at the aforementioned travelling direction of the aforementioned incident light, and the 1st direction of the above may impress the magnetic field of the 2nd different direction at the aforementioned magneto optics crystal and may not interrupt the aforementioned optical path of the aforementioned incident light, and are adjustable.
[Claim 2] The direction of the magnetic field which the aforementioned permanent magnet impresses to the aforementioned magneto optics crystal (the 1st direction of the above) is a Faraday-rotation child according to claim 1 characterized by being within the limits of zero - 45 degrees to the travelling direction of the aforementioned incident light.
[Claim 3] The direction of the magnetic field which the aforementioned electromagnet impresses to the aforementioned magneto optics crystal (the 2nd direction of the above) is a Faraday-rotation child according to claim 1 or 2 characterized by being within the limits of zero - 45 degrees to a direction perpendicular to the travelling direction of the aforementioned incident light.
[Claim 4] The direction of each magnetic field which the aforementioned permanent magnet and the aforementioned electromagnet impress to the aforementioned magneto optics crystal (the 1st direction of the above and the 2nd direction of the above) is the Faraday-rotation child of any one publication of the claim 1-3 characterized by lying at right angles mutually.
[Claim 5] At least two aforementioned permanent magnets are the Faraday-rotation children of any one publication of the claim 1-4 characterized by being prepared and being mutually arranged focusing on the aforementioned magneto optics crystal at the symmetric position.
[Claim 6] At least two aforementioned permanent magnets are the Faraday-rotation children of any one publication of the claim 1-4 characterized by being prepared and being mutually arranged to the aforementioned optical path of the aforementioned incident light at the symmetric position.
[Claim 7] The configuration of the aforementioned permanent magnet is the Faraday-rotation child of any one publication of the claim 1-6 characterized by being the square pole-like.
[Claim 8] The magnetic field which the aforementioned permanent magnet impresses to the aforementioned magneto optics crystal is the Faraday-rotation child of any one publication of the claim 1-7 characterized by being parallel to the aforementioned optical path.
[Claim 9] The magnetic field which the aforementioned electromagnet impresses to the aforementioned magneto optics crystal is the Faraday-rotation child of any one publication of the claim 1-8 characterized by the perpendicular thing to the aforementioned optical path.
[Claim 10] The configuration of the aforementioned magneto optics crystal is the Faraday-rotation child of any one publication of the claim 1-9 characterized by being a globular form.
[Claim 11] The aforementioned magneto optics crystal is the Faraday-rotation child of any one publication of the claim 1-10 characterized by being the single crystal of YIG.
[Claim 12] Optical equipment which contains in part the Faraday-rotation child with the Faraday-rotation angle of an incident light strange good characterized by providing the following. The aforementioned Faraday-rotation child is a

magneto optics crystal which is transparent and has magnetism to the aforementioned incident light. The permanent magnet to which the magnetic field of the 1st direction which is parallel or intersects the travelling direction of the aforementioned incident light is impressed to the aforementioned magneto optics crystal, it is arranged so that the optical path of the aforementioned incident light may not be interrupted, and magnetic saturation of the aforementioned magneto optics crystal is carried out. The electromagnet magnetic field strength and whose direction it is arranged so that it is a perpendicular or the crossing direction at the aforementioned travelling direction of the aforementioned incident light, and the 1st direction of the above may impress the magnetic field of the 2nd different direction at the aforementioned magneto optics crystal and may not interrupt the aforementioned optical path of the aforementioned incident light, and are adjustable.

[Claim 13] The optical attenuator containing a Faraday-rotation child with the Faraday-rotation angle of the incident light characterized by providing the following strange good, and the polarizer to which the transparency intensity of the aforementioned incident light is changed according to the rotatory polarization angle rotated by this Faraday-rotation child. The aforementioned Faraday-rotation child is a magneto optics crystal which is transparent and has magnetism to the aforementioned incident light. The permanent magnet to which the magnetic field of the 1st direction which is parallel or intersects the travelling direction of the aforementioned incident light is impressed to the aforementioned magneto optics crystal, it is arranged so that the optical path of the aforementioned incident light may not be interrupted, and magnetic saturation of the aforementioned magneto optics crystal is carried out. The electromagnet magnetic field strength and whose direction it is arranged so that it is a perpendicular or the crossing direction at the aforementioned travelling direction of the aforementioned incident light, and the 1st direction of the above may impress the magnetic field of the 2nd different direction at the aforementioned magneto optics crystal and may not interrupt the aforementioned optical path of the aforementioned incident light, and are adjustable.

[Claim 14] The optical modulator containing a Faraday-rotation child with the Faraday-rotation angle of the incident light characterized by providing the following strange good, the polarizer to which the transparency intensity of the aforementioned incident light is changed according to the rotatory polarization angle rotated by this Faraday-rotation child, and the modulation control means to which the aforementioned Faraday-rotation angle is changed in time. The aforementioned Faraday-rotation child is a magneto optics crystal which is transparent and has magnetism to the aforementioned incident light. The permanent magnet to which the magnetic field of the 1st direction which is parallel or intersects the travelling direction of the aforementioned incident light is impressed to the aforementioned magneto optics crystal, it is arranged so that the optical path of the aforementioned incident light may not be interrupted, and magnetic saturation of the aforementioned magneto optics crystal is carried out. The electromagnet magnetic field strength and whose direction it is arranged so that it is a perpendicular or the crossing direction at the aforementioned travelling direction of the aforementioned incident light, and the 1st direction of the above may impress the magnetic field of the 2nd different direction at the aforementioned magneto optics crystal and may not interrupt the aforementioned optical path of the aforementioned incident light, and are adjustable.

[Claim 15] The optical switch in which the Faraday-rotation angle of an incident light characterized by providing the following includes a change means to penetrate the light of the polarization state of the above 1st and to intercept the light of the polarization state of the above 2nd with adjustable with the Faraday-rotation child who changes this incident light into the 1st polarization state and the 2nd polarization state. The aforementioned Faraday-rotation child is a magneto optics crystal which is transparent and has magnetism to the aforementioned incident light. The permanent magnet to which the magnetic field of the 1st direction which is parallel or intersects the travelling direction of the aforementioned incident light is impressed to the aforementioned magneto optics crystal, it is arranged so that the optical path of the aforementioned incident light may not be interrupted, and magnetic saturation of the aforementioned magneto optics crystal is carried out. The electromagnet magnetic field strength and whose direction it is arranged so that it is a perpendicular or the crossing direction at the aforementioned travelling direction of the aforementioned incident light, and the 1st direction of the above may impress the magnetic field of the 2nd different direction at the aforementioned magneto optics crystal and may not interrupt the aforementioned optical path of the aforementioned incident light, and are adjustable.

[Claim 16] The aforementioned change means is an optical switch according to claim 15 characterized by changing the travelling direction of the light of the polarization state of the above 2nd.

[Claim 17] A polarization controller equipped with a polarization monitor means to detect the polarization state of the output light from the Faraday-rotation child with a Faraday-rotation angle strange good and this Faraday-rotation child of the incident light characterized by providing the following, and the control means which control the rotatory polarization angle of the aforementioned incident light based on the polarization state detected by this polarization monitor means. The aforementioned Faraday-rotation child is a magneto optics crystal which is transparent and has magnetism to the aforementioned incident light. The permanent magnet to which the magnetic field of the 1st direction

which is parallel or intersects the travelling direction of the aforementioned incident light is impressed to the aforementioned magneto optics crystal, it is arranged so that the optical path of the aforementioned incident light may not be interrupted, and magnetic saturation of the aforementioned magneto optics crystal is carried out. The electromagnet magnetic field strength and whose direction it is arranged so that it is a perpendicular or the crossing direction at the aforementioned travelling direction of the aforementioned incident light, and the 1st direction of the above may impress the magnetic field of the 2nd different direction at the aforementioned magneto optics crystal and may not interrupt the aforementioned optical path of the aforementioned incident light, and are adjustable.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] Especially this invention relates to the Faraday-rotation child of the method controlled by changing the magnetic field which impresses the Faraday-rotation angle to a magneto optics crystal about a Faraday-rotation child. Furthermore, it is related with the various optical equipments of an optical attenuator or an optical modulator equipped with such a Faraday-rotation child in part.
[0002]
[Description of the Prior Art] A Faraday-rotation child is an element for controlling the polarization state of light using the Faraday effect that plane of polarization rotates, in case light passes through the inside of a magnetic field parallel to the travelling direction. Generally, a Faraday-rotation child consists of a magnetic field impression means for making the magneto optics crystal which has magnetization, and this magneto optics crystal produce magnetization, and rotates the plane of polarization of light by making light pass through the interior of a magneto optics crystal which magnetization produced. The angle which plane of polarization rotated is called Faraday-rotation angle by having passed the magneto optics crystal.
[0003] Since especially the above Faraday-rotation children change a magnetization component parallel to the travelling direction of the light produced inside a magneto optics crystal by controlling the magnetic field impressed by the magnetic field impression means and a Faraday-rotation angle can be controlled, it is mostly used as a controlling element of polarization.
[0004] Such an element can realize various optical equipments, such as an arbitrary sensing element of polarization, an optical switch, an optical modulator, and an optical attenuator, by combining with polarization separation / selection elements, such as polarization sensing elements, such as a wavelength plate, and a polarizer.
[0005] Drawing 7 is the conventional Faraday-rotation child's block diagram. In this drawing, in order to impress a magnetic field to the sheet metal-like magneto optics crystal 70, the electromagnet 72 which consists of a permanent magnet 71, and a magnetic core 73 and a coil 74 is formed. The power supply 75 which can change voltage and polarity is connected to a coil 74, and current is supplied to a coil 74.
[0006] A permanent magnet 71 impresses a magnetic field to a longitudinal direction to an optical path 76, and the electromagnet 72 is impressing the magnetic field parallel to an optical path 76. By changing the polarity of a power supply 75, the south pole and N pole of an electromagnet 72 can be replaced.
[0007] Moreover, the optical passage slot 77 is formed, and it is constituted by the magnetic core 73 so that light may pass along a part for this slot so that an optical path 76 may not become obstructive. With this composition, in order to prevent the angle of rotation of polarization of light changing with a Faraday-rotation child's magnetization unsaturations discontinuously, it not only changes a magnetic field parallel to the travelling direction of light with an electromagnet, but it is impressing the fixed magnetic field by the permanent magnet to it and a longitudinal direction. By this, a Faraday-rotation child's magnetization is saturated also during switch operation of a magnetic field.
[0008] The saturation of magnetization is explained using a drawing. Drawing 8 (a) shows the magnetic hysteresis loop of the magnetic substance. If a magnetic field H is applied to the magnetic substance, spontaneous magnetization will arise. Drawing 8 (a) is Hm about the strength of a magnetic field H. - Hm It is obtained by measuring the size of the magnetization M at the time of making it go in between. As shown in the magnetic-saturation section of this drawing, if the strength of a magnetic field H becomes a predetermined size, Magnetization M will stop becoming large more than it, and will start magnetic saturation.
[0009] When a path like [when the strength of a magnetic field H becomes large gradually] the root (1) is followed and the strength of a magnetic field H becomes small gradually, Magnetization M follows a path like the root (2), and changes.

[0010] In the Faraday-rotation child of drawing 7 , when changing the current passed in a coil 74 in order to change a Faraday-rotation angle supposing the permanent magnet 71 is not formed, magnetization of the magneto-optics-crystal 70 interior changes, as shown in the hysteresis loop of drawing 8 (a). By the way, since the flux density of the magneto-optics-crystal 70 interior adds a magnetic field and magnetization, the flux density with the same size of the magnetic field to impress produced inside a magneto optics crystal 70 but will have a different value. Since a Faraday-rotation angle is determined by the flux density produced inside a magneto optics crystal 70, even if it is impressing the magnetic field of the same strength, a different Faraday-rotation angle will be acquired and control will become difficult.

[0011] Drawing 8 (b) is drawing explaining the magnetic domain inside the magnetic substance. The magnetic domain 81 surrounded by the magnetic domain wall 80 exists in the interior of the magnetic substance, and it has the magnetization (this drawing is shown by the arrow) whose each had original strength and an original direction. The state where the magnetic field was impressed to the magnetic substance of the state of this drawing is drawing 8 (c).

[0012] Magnetization of various directions and strength which each magnetic domain had makes the same direction the other side gradually as the magnetic field strength impressed to the magnetic substance becomes strong. In drawing 8 (c), it is shown that the direction of magnetization of a magnetic domain shown by reference numbers 82-86 is rotating compared with drawing 8 (b). Rotation of the direction of this magnetization appears as a discontinuous change of magnetization of the whole magneto optics crystal, and changes the size of flux density discontinuously.

[0013] The magnetic field strength impressed becomes strong, and the magnetic domain 81 to which the direction of magnetization was equal, and the magnetic domain wall between 82-86 disappear automatically, and become one big magnetic domain. furthermore -- if an impression magnetic field becomes strong -- gradually -- a magnetic domain 81 -- large -- becoming -- just -- being alike -- the whole magnetic substance will become like one magnetic domain Such a state is in the state of magnetic saturation.

[0014] In the root (1) shown in drawing 8 (a) according to the cause which was described above, and (2), irregularity has arisen in the hysteresis loop. Thus, though the strength of a magnetic field H is changed continuously, when Magnetization M changes discontinuously, flux density will also change discontinuously. If such a thing happens, the Faraday-rotation angle of the light which passes through the inside of a magneto optics crystal will also change discontinuously.

[0015] Then, a permanent magnet 71 is formed, and the magnetic field strength which doubled the magnetic field which the magnetic field which an electromagnet 72 adds, and a permanent magnet 71 add consists of Faraday-rotation children of drawing 7 so that magnetic saturation of the magneto optics crystal 70 may always be carried out.

[0016] Since the size of magnetization is fixed even if magnetic field strength changes in the state of magnetic saturation, as shown in drawing 8 (a), flux density does not change discontinuously and a Faraday-rotation angle is not changed discontinuously.

[0017] When changing a Faraday-rotation angle, the magnetic field strength which controls the current which flows in a coil 74 and an electromagnet 72 makes is changed. By adding in vector the magnetic field which an electromagnet 72 makes, and the magnetic field which a permanent magnet 71 makes, the direction of the magnetic field impressed to a magneto optics crystal 70 is changed. Therefore, magnetization will be hung by the magnetic field while it had been saturated, a direction will be changed, a magnetization component parallel to an optical path 76 will change, and a Faraday-rotation angle changes.

[0018]

[Problem(s) to be Solved by the Invention] Drawing 9 is drawing explaining the conventional Faraday-rotation child's trouble. In the Faraday-rotation child of drawing 7 , by the conventional Faraday-rotation child, it must arrange so that the magnetic core of an electromagnet may not interfere with the passage way of light as the optical passage slot 77 is established in the magnetic core 73 of an electromagnet 72.

[0019] Like drawing 9 (a), in order to impress a magnetic field parallel to an optical path 76, the electromagnet 72 is formed so that magnetic core 73' may turn to the upper and lower sides of a magneto optics crystal 70. Therefore, magnetic core 73' all cannot arrange the upper surface and the undersurface of a magneto optics crystal 70 to the method of a wrap so that an optical path 76 may not be interrupted.

[0020] On the other hand, in order to impress the magnetic field of a direction perpendicular to an optical path 76, the permanent magnet 71 is formed so that the side of a magneto optics crystal 70 may be worn. Since a permanent magnet 71 does not need to avoid an optical path 76, it can be wearing the whole side surface of a magneto optics crystal 70, and it can impress the uniform magnetic field 90 to a magneto optics crystal 70.

[0021] Drawing 9 (b) is drawing which looked at this drawing (a) from the upper part, and the place in which magnetic core 73' of an electromagnet 72 avoids an optical path 76, and is prepared is shown. Thus, since a part of upper surface of a magneto optics crystal 70 and undersurface are opened for the optical path 76, magnetic core 73' cannot be

constituted so that the upper surface and the undersurface of a magneto optics crystal 70 may be worn extensively, and a uniform magnetic field cannot be impressed.
[0022] Drawing 9 (c) is drawing showing the situation of the magnetic field which an electromagnet 72 impresses to a magneto optics crystal 70. Since magnetic core 73' is prepared so that an optical path 76 may be avoided as shown in this drawing, it bypasses greatly and the magnetic field 91 which came from N pole of an electromagnet 72 results in the south pole of an electromagnet 72 while permeating into a magneto optics crystal 70. Thus, since a magnetic field 91 permeates in the form where the line of magnetic force swells, into a magneto optics crystal 70, the flux density produced inside a magneto optics crystal 70 also becomes uneven. Unevenly, with a bird clapper, the flux density of the magneto-optics-crystal 70 interior has a bad influence on a Faraday-rotation angle, and makes control of a Faraday-rotation angle difficult.
[0023] When it is going to make uniform the magnetic field of a direction parallel to the optical path 76 by the electromagnet, the optical passage slot 77 is established in a magnetic core 73, and it must be made to have to wear the upper surface or the undersurface of a magneto optics crystal by the magnetic pole of a magnetic core 73 as much as possible like drawing 7 . In this case, although forming a uniform magnetic field by preparing two electromagnets is also considered, generally an electromagnet will be larger than a permanent magnet, and the Faraday-rotation child itself will enlarge it. Moreover, establishing structure like the optical passage slot 77 also takes time and effort, and it has the side in which a manufacturing cost is attached highly.
[0024] Thus, by the conventional magnetic field impression method, the inclination which the equipment which the magnetic field impressed to a magneto optics crystal did not become uniform since the magnetic core of an electromagnet avoided an optical path and was installed, and includes optical system, such as a lens, with enlargement of a Faraday-rotation child enlarges was suited.
[0025] Therefore, the technical problem of this invention is offering the Faraday-rotation child who can impress a uniform magnetic field to a magneto optics crystal, and can moreover also stop the size of the whole equipment small.
[0026]
[Means for Solving the Problem] In order to control plane of polarization by this invention efficiently in a uniform magnetic field, first The direction of a magnetic field of the permanent magnet for suppressing a Faraday-rotation child's magnetization unsaturation is made into the 1st direction which is parallel or intersects the travelling direction of light. The main part of a permanent magnet is arranged so that an optical path may not be interrupted, the direction of an impression magnetic field by the electromagnet is made into the 2nd direction which is a perpendicular or a crossing direction and is different from the 1st direction of the above at the travelling direction of light, and it arranges so that a magnetic core may not interrupt an optical path. Consequently, since the magnetic core (yoke) of a permanent magnet or an electromagnet can be arranged without making a hole in a permanent magnet or an electromagnet, the magnetic field impressed to a magneto optics crystal can be made uniform.
[0027] Moreover, equalization of the magnetic field impressed to a magneto optics crystal, using a permanent magnet two or more is attained. Since a permanent magnet can make a strong magnetic field even if it is small compared with an electromagnet, though equalization of a magnetic field is attained by preparing more than one, a Faraday-rotation child does not enlarge.
[0028] Since it is not necessary to prepare two or more electromagnets in order to make uniform the magnetic field impressed with an electromagnet, enlargement of a Faraday-rotation child can be suppressed further. In other sides of this invention, in order to avoid that a magnetic field becomes uneven by the demagnetizing field inside the magneto optics crystal which is the magnetic substance which has magnetization, let the configuration of the magneto optics crystal itself be a sphere. That is, since change of the strength of the demagnetizing field by the impression direction of a magnetic field changing can be prevented, the magnetic field impressed to a magneto optics crystal can be made more into homogeneity.
[0029]
[Embodiments of the Invention] Drawing 1 is drawing explaining the situation of the magnetic field impressed to the composition and the magneto optics crystal of one example of this invention.
[0030] In this example, the configuration of a magneto optics crystal 10 serves as the square pole. Although especially the magneto optics crystal used for a Faraday-rotation child is not limited, there is much what is formed by YIG (Y3 Fe5 O12; yttrium iron garnet) practical. or it replaced by YIG by the terbium, the bismuth, etc. (BiX Tb3-X) -- Fe 5O12 and 3 (TbHoBi) Fe5 O12 grade are used
[0031] Although the Faraday-rotation child of this example has the conventional same component as a thing, i.e., a permanent magnet, and a conventional electromagnet, the arrangement differs. As shown in drawing 1 (a), the magnetic core 15 of an electromagnet 13 is formed in the side of a magneto optics crystal 10, and has the composition of impressing a lateral magnetic field to an optical path 14. Similarly permanent magnets 11 and 12 are formed in the

side of a magneto optics crystal 10, and the configuration also serves as the square pole. In this composition, permanent magnets 11 and 12 are formed in order to impress a magnetic field in the direction parallel to an optical path 14, and they are prepared two pieces in accordance with the side in which a magneto optics crystal 10 faces so that the magnetic field impressed to a magneto optics crystal 10 may become more uniform further.

[0032] By arranging, as shown in drawing 1 (a), a permanent magnet does not become the obstacle of an optical path 14, and even if it prepares two pieces, it does not lead to enlargement of the whole Faraday-rotation child, while being able to obtain a uniform magnetic field easily, since it is small and is powerful.

[0033] Moreover, although an electromagnet 13 has a coil 16 and a power supply 17 and the magnetic core 15 also tends to become large Since it became unnecessary to turn a magnetic core 15 up the form where an optical path 14 is avoided and the configuration of the side of a magneto optics crystal 10 and the configuration of a magnetic core 15 can be made isomorphous by having considered as the composition which impresses a magnetic field to the longitudinal direction of an optical path 14 One electromagnet 13 can impress a uniform magnetic field to a magneto optics crystal 10 only by preparing.

[0034] That is, in the physical relationship of the magnetic core 15 of an electromagnet 13, and an optical path 14, by having made it impress the magnetic field by the electromagnet 13 from the longitudinal direction of an optical path 14, the magnetic core 15 of an electromagnet 13 can be approached and used for a magneto optics crystal 10, consequently advantages, such as reduction of drive current and equalization of an impression magnetic field, can be acquired.

[0035] Drawing 1 (b) shows the situation of the magnetic field which an electromagnet 13 impresses to a magneto optics crystal 10. As shown in this drawing, since both south pole and N poles of a magnetic core 15 are constituted so that the side of a magneto optics crystal 10 may be worn on the whole, the line of magnetic force becomes almost parallel, and the impression magnetic field 18 is a uniform magnetic field.

[0036] On the other hand, drawing 1 (c) shows the situation of the magnetic field which a permanent magnet impresses to a magneto optics crystal. As shown in this drawing, permanent magnets 11 and 12 are formed so that a magneto optics crystal 10 may be inserted from both sides. Each south pole and N pole of permanent magnets 11 and 12 have turned to [both] the same direction, and have the composition of impressing the magnetic field of the fixed direction to a magneto optics crystal 10. The line of magnetic force of the permanent magnets 11 and 12 shown in drawing comes from N pole of each permanent magnet 11 and 12, bypasses the exterior of permanent magnets 11 and 12, and results in each south pole. As line of magnetic force results in the south pole from each N pole, it passes along the magneto optics crystal 10, consequently a magnetic field parallel to an optical path is impressed to a magneto optics crystal 10.

[0037] Since the side of permanent magnets 11 and 12 is formed in the same configuration as a magneto optics crystal 10 and is prepared in the both-sides side which faces as shown in drawing 1 (a), a uniform magnetic field can be impressed over the whole magneto optics crystal 10.

[0038] LPE (Liquid Phase Epitaxial) for which many magneto optics crystals 10 are used until now 3(FeAlGa)5O12 which is the crystal which grows by the method (GdBi) etc., when material is used It is standard to have the plane of incidence which has the thickness of 300-500 micrometers equivalent to the distance taken for plane of polarization to rotate 45 degrees in an incident light with a wavelength of 1.55 micrometers generally, and had the area about 1mm in all around in the size of an incident ray.

[0039] As a configuration of the magneto optics crystal 10 of this example, three sides are the cubes which are about 2mm, for example. the size of the permanent magnets 11 and 12 at this time is about 2x2x4mm, an electromagnet 15 is set to about 8x10x4mm, and its permanent magnet is alike and smaller therefore, in order to obtain a uniform magnetic field in the conventional composition, compared with the case where two or more electromagnets are used, composition like this example can boil a Faraday-rotation child's size markedly, and can make it small

[0040] Drawing 2 is drawing showing the relation of magnetization between the magnetic field impressed with an electromagnet and a permanent magnet, and a magneto optics crystal. The magnetic field by the electromagnet does not have this drawing (a), and it shows the case where only the magnetic field by the permanent magnet exists. The magnetic field impressed to a magneto optics crystal 10 is based on a permanent magnet, and is parallel to an optical path 21. Although the magnetization 23 produced by this impression magnetic field 22 is parallel to an optical path 21 similarly, magnetization 23 is saturated for the impression magnetic field 22 by the permanent magnet.

[0041] When incidence of the light in alignment with the optical path 21 is carried out to the magneto optics crystal 10 of this state, a Faraday-rotation angle serves as the greatest size. This drawing (b) shows the case where the magnetic field by the electromagnet exists.

[0042] Since the magnetic field by the permanent magnet has the fixed size, although the component of a magnetic field parallel to an optical path 21 does not change, the impression magnetic field 22 impressed to a magneto optics

crystal 10 since the magnetic field by the electromagnet is impressed to the longitudinal direction becomes what compounded these two magnetic fields in vector, as shown in this drawing.

[0043] The magnetization 23 produced in a magneto optics crystal 10 becomes what became parallel to an impression magnetic field, therefore inclined to the optical path 21. Although the strength of the impression magnetic field 22 becomes large, since it is already saturated by the magnetic field according [the magnetization 23 of the magneto-optics-crystal 10 interior] to a permanent magnet, the size of magnetization 23 self does not change.

[0044] Therefore, magnetization 23 changes only a direction in the direction parallel to an impression magnetic field, without changing the size. By this, a component parallel to the optical path 21 of magnetization 23 becomes smaller than the case of this drawing (a), and a Faraday-rotation angle becomes small similarly.

[0045] This drawing (c) shows the case where the magnetic field by the electromagnet is made stronger than this drawing (b). As described above, the impression magnetic field 22 impressed to a magneto optics crystal 10 is composition of the magnetic field by the permanent magnet with which the size was fixed, and the magnetic field by the electromagnet, and, in the case of this drawing (c), is the largest compared with the case where the sizes of the impression magnetic field 22 are this drawing (a) and (b). If this impression magnetic field 22 is impressed to a magneto optics crystal 10, the magnetization 23 parallel to the impression magnetic field 22 will arise. However, since magnetization 23 is already saturated, the size of magnetization does not change. Thereby, a component parallel to the optical path 21 of magnetization 23 becomes smaller than which [of this drawing (a) and (b)] case. Therefore, a Faraday-rotation angle also becomes smaller than which [above-mentioned] case.

[0046] Thus, a Faraday-rotation angle is controllable by changing the size of the magnetic field impressed to a magneto optics crystal 10 with an electromagnet. For example, if a Faraday-rotation angle when only the magnetic field of a permanent magnet is impressed is set up with 45 degrees, the control range of a Faraday-rotation angle will become 0 degree - 45 degrees.

[0047] Drawing 3 is drawing explaining the composition and its operation of the modification of the example of drawing 1 . In the composition of this drawing (a), permanent magnets 11 and 12 and the electromagnet 13 incline from a perpendicular direction to an optical path 14 and a magneto optics crystal 10.

[0048] Thus, although all each magnetic field which permanent magnets 11 and 12 and an electromagnet 13 impress to a magneto optics crystal 10 serves as parallel or a perpendicular in an optical path 14 by inclining, since the magnetic field impressed to a magneto optics crystal 10 compounds these magnetic fields, it has the same operation as the example of drawing 1 .

[0049] Moreover, it is not restricted to a method as shown in this drawing (a), an electromagnet 13 and permanent magnets 11 and 12 are made to incline to an optical path 14 independently, respectively, and the inclination method of permanent magnets 11 and 12 and an electromagnet 13 can also be installed. In this case, an electromagnet 13 should just set up the magnetic field impressed to a magneto optics crystal 10 practical at the arbitrary angles to the state which inclined from the perpendicular state about 45 degrees to the optical path. Similarly, permanent magnets 11 and 12 should just set up the magnetic field impressed to a magneto optics crystal 10 at the arbitrary angles to the state which inclined about 45 degrees from the state parallel to an optical path 14.

[0050] However, it is required to prepare so that permanent magnets 11 and 12 and a magnetic core 15 may interrupt an optical path 14 for neither of the cases. When an electromagnet 13 and permanent magnets 11 and 12 incline greatly and come to interrupt an optical path 14, it is necessary to make the optical path for changing the configuration of a magnetic core 15 or permanent magnets 11 and 12, and light passing. However, if it is made to incline so that each configuration must be changed in this way, the magnetic field formed like the conventional Faraday-rotation child of drawing 7 becomes less uniform, and since it comes to affect a Faraday-rotation angle, it is not desirable.

[0051] This drawing (b) is drawing explaining the situation of the magnetization produced by the magnetic field impressed to a magneto optics crystal by composition of this drawing (a), and this magnetic field. Being shown in the left-hand side of this drawing (b) shows the impression magnetic field which are the magnetic fields formed with an electromagnet 13 and permanent magnets 11 and 12, and these composition. ** The arrow shown is a magnetic field formed with permanent magnets 11 and 12, and when the magnetic field by the electromagnet 13 does not exist, this magnetic field turns into an impression magnetic field to a magneto optics crystal 10. When the magnetic field where an electromagnet 13 is shown by the arrow of (1) is being impressed, the impression magnetic field to a magneto optics crystal 10 becomes like **. When similarly the magnetic field where an electromagnet 13 is shown by (2) is being impressed, an impression magnetic field becomes like **.

[0052] The magnetization produced corresponding to the impression magnetic field of these **s - ** is shown in the right-hand side of this drawing (b). As mentioned above, the size of magnetization ** - ** is the same, and only directions differ. Although a component parallel to the optical path 14 of magnetization ** and ** is downward as cut by future, the component parallel to the optical path 14 of magnetization ** serves as facing up. Since Faraday rotation

produced by magnetization ** and ** is downward [with both the same components parallel to the optical path 14], although the sizes of an angle of rotation differ, the direction of rotatory polarization is the same. Faraday rotation which a component parallel to an optical path 14 produces by magnetization ** opposite to magnetization ** and ** on the other hand becomes contrary to the hand of cut according [a hand of cut] to magnetization ** and **.

[0053] Thus, it becomes possible by inclining and forming an electromagnet 13 and permanent magnets 11 and 12 to an optical path 14, to make reverse the direction of rotatory polarization of an incident light. Drawing 4 is the block diagram of other examples of the Faraday-rotation child of this invention. In this drawing, the same reference number is given to the same component as the example of drawing 1 .

[0054] The configuration of a magneto optics crystal 40 is made into the globular form in this example. Other composition is the same as that of the above-mentioned example and a modification, and can be composition especially the thing that it inclines and is established for a magnetic core 15 and permanent magnets 11 and 12 to an optical path 14, and its same is said of the operation obtained in that case.

[0055] In an above-mentioned example and the above-mentioned example of composition, although it is improving compared with the conventional method in respect of the homogeneity of the magnetic field in a magneto optics crystal, in order to suppress the influence of change of the demagnetizing field produced in the magneto-optics-crystal 40 interior when the direction of the magnetic field impressed further changes in this example, the configuration of a magneto optics crystal 40 is made into a globular form. If the configuration of a magneto optics crystal 40 is made into a globular form, a direction dependency will be lost in the configuration of a magneto optics crystal 40. Since demagnetizing field change the strength etc. with the configuration of the magnetic substance, by making a configuration into a globular form without a direction dependency, the direction dependency of it is lost also to demagnetizing field, and they can impress a uniform magnetic field in efficiency by the whole.

[0056] Drawing 5 is drawing for explaining behavior of demagnetizing field. As for this drawing (a) and (b), a configuration shows the magnetization 50 generated inside the magneto optics crystal 10 of the square pole, demagnetizing field 51-1, and the situation of 51-2. The case where demagnetizing field 51-1 have occurred in parallel with the side of a magneto optics crystal 10 is shown in this drawing (a). This is produced when the magnetic field impressed with an electromagnet and a permanent magnet is parallel to the side of a magneto optics crystal 10. On the other hand, the magnetic field where this drawing (b) is impressed with an electromagnet and a permanent magnet shows the case where the direction of the diagonal line of a magneto optics crystal 10 is turned to, and has also produced demagnetizing field 51-2 in the direction of the diagonal line of a magneto optics crystal 10.

[0057] In this case, it becomes a strong thing from the demagnetizing field 51-2 produced when the direction of the demagnetizing field 51-1 which are produced in the case of this drawing (a) is this drawing (b). In this invention, magnetization 50 is used in the state where it was always saturated, and is controlling the Faraday-rotation angle by changing the direction of magnetization 50. However, if the demagnetizing field 51-1 produced to the direction and opposite direction of magnetization 50 and the strength of 51-2 change with directions, the magnetic field currently impressed to the magneto optics crystal 10 will become a little uneven. Therefore, it will have some bad influence on a Faraday-rotation angle.

[0058] On the other hand, this drawing (c) and (d) show the demagnetizing field 51-3 at the time of making the configuration of a magneto optics crystal 10 into a globular form, and the situation of 51-4. In the case of the magneto optics crystal 40 which carried out the globular form, since a configuration does not have a direction dependency, there is no difference at the strength of the demagnetizing field 51-3 in the case of this drawing (c), and the strength of the demagnetizing field 51-4 in the case of this drawing (d). Therefore, though the direction which adds a magnetic field to a magneto optics crystal 40 is changed, since change does not arise in demagnetizing field 51-3 and the strength of 51-4, an impression magnetic field can be impressed uniformly. Therefore, it becomes possible to control a Faraday-rotation angle more easily.

[0059] Thus, according to the example of drawing 4 , the magnetic field impressed to a magneto optics crystal can be further made into homogeneity, without enlarging a Faraday-rotation child. However, although not illustrated, the magneto optics crystal itself comes to work as a lens to light by having made the configuration of a magneto optics crystal 40 into the globular form. Therefore, when including the Faraday-rotation child using the globular form magneto optics crystal 40 in an optical instrument, the system design which took this into consideration beforehand is required.

[0060] Drawing 6 is drawing for explaining an optical switch, an optical attenuator, an optical modulator, and a polarization controller as an application to the optical equipment of the Faraday-rotation child of this invention. Composition common to each of an optical switch, an optical attenuator, and an optical modulator is shown in this drawing (a).

[0061] In constituting an optical switch, 45 degrees of polarizers 61 and 62 of each other are leaned, and the Faraday-

rotation child 60 constitutes so that the plane of polarization of light may be switched between +45 degrees and -45 degrees. For convenience, light considers as the thing of explanation which carries out incidence from a polarizer 61 side, and makes the angle measured clockwise the degree of positive angle seen from the direction of incidence of light here. Moreover, the path is shown by the optical path 57 as light.

[0062] The light which has passed the polarizer 61 is the linearly polarized light with specific plane of polarization. if this light carries out incidence to the Faraday-rotation child 60 -- plane of polarization -- +45 degrees -- or -45 degrees is rotated Suppose that the polarizer 62 was installed so that the light which rotated +45 degrees of plane of polarization of the light which passed the polarizer 61 might be passed. Although a polarizer 62 can be passed at this time if light can give a +45-degree Faraday-rotation angle by the Faraday-rotation child 60, a polarizer 62 cannot be passed when a -45-degree Faraday-rotation angle is given. Thus, the optical switch which performs ON/OFF of an optical output can consist of setting up the Faraday-rotation angle given to light so that it may become a dispersed predetermined value.

[0063] Or the optical switch which performs not the change of an optical output but the change of an optical path can also be constituted by transposing a polarizer 62 to a polarization eliminator etc. by making light go straight on, when a Faraday-rotation angle is +45 degrees, being able to bend the travelling direction of light at the time of -45 degrees, and doing in this way.

[0064] Moreover, Faraday-rotation angle by the Faraday-rotation child 60 - If it is made to make it change to continuation to theta-+theta (here, for theta to be the value of the angle set up arbitrarily), the optical output obtained from a polarizer 62 will change to continuation according to the Faraday-rotation angle given by the Faraday-rotation child. For example, when set as the same relation as the case where polarizers 61 and 62 are the above-mentioned optical switches, by changing a Faraday-rotation angle continuously from +45 degrees to -45 degrees, it can change into the state where an optical output is attenuated gradually and there is no optical output, and an optical attenuator can be constituted.

[0065] Moreover, the control unit (un-illustrating) of exclusive use is formed, and it is made to change control of the Faraday-rotation angle by the Faraday-rotation child 60 continuously and in time. If it does in this way, since the optical output obtained from a polarizer 62 will become like the signal to which intensity is changed in time, an optical modulator can consist of composition shown in this drawing (a).

[0066] This drawing (b) is an example of the block diagram of a polarization controller. This polarization controller consists of the coupler 63 which divides the light outputted by the Faraday-rotation child 60, the polarization eliminator 64 which separates P polarization and S polarization, optical detectors 65 and 66 which detect S polarization and each P polarization, and a control circuit 67 which controls the Faraday-rotation child's 60 Faraday-rotation angle based on the detection result of optical day DEKUTA 65 and 66 besides the Faraday-rotation child 60 and a polarizer 61. These elements are divided into the polarization control section 59 which consists of a coupler 63, the polarization eliminator 64, the polarization monitor section 58 and the Faraday-rotation child 60 that consist of optical detectors 65 and 66, a polarizer 61, and a control circuit 67.

[0067] First, with the polarizer 61 of a polarization control section, the lightwave signal 69 which carried out incidence from the polarizer 61 side is made into the linearly polarized light, and, similarly carries out incidence to the Faraday-rotation child 60 of a polarization control section. In the Faraday-rotation child 60, predetermined carries out angle rotation of the plane of polarization of a lightwave signal 69, and a polarization state is changed.

[0068] It separates into two beams of light in the coupler 63 of the polarization monitor section, without changing the polarization state of the lightwave signal 69 outputted by the Faraday-rotation child 60. Incidence of one side of the separated lightwave signal is carried out to the polarization eliminator 64, and it is divided into S polarization and P polarization. The optical detector 65 detects the luminous intensity of S polarization, and the optical detector 66 detects the optical intensity of P polarization. The lightwave signal 69 outputted by the Faraday-rotation child 60 was divided into S polarization component and P polarization component which intersect perpendicularly mutually, and the polarization state of the lightwave signal 69 outputted by the Faraday-rotation child 60 is detected by detecting the optical intensity.

[0069] The optical intensity of each polarization which the optical detectors 65 and 66 detected is sent to the control circuit 67 of a polarization control section as a detecting signal. In a control circuit 67, the polarization state of the lightwave signal 69 currently outputted by the Faraday-rotation child 60 based on the optical intensity of S polarization and the optical intensity of P polarization is computed, the amount of current supply sources to the electromagnet needed in order to change into a desired polarization state is calculated, and the Faraday-rotation child 60 is given as a control signal 68.

[0070] According to a control signal 68, current is supplied to an electromagnet, and a Faraday-rotation angle is controlled by the Faraday-rotation child 60. Thus, the lightwave signal 69 which has a desired polarization state can be

obtained by composition of this drawing (b).

[0071] As mentioned above, if the various above optical equipments are constituted using the Faraday-rotation child of this invention who can impress a uniform magnetic field to a magneto optics crystal, stopping element size small, a miniaturization and highly-precise-izing of the whole equipment are simultaneously realizable.

[0072]

[Effect of the Invention] According to this invention, a uniform magnetic field can be impressed to the magneto optics crystal which light penetrates, it is small and an adjustable angle-of-rotation Faraday-rotation child with easy mounting becomes possible.

[0073] Since it prepares so that it may not carry out using two or more expensive electromagnets, but a cheap and small permanent magnet may be used and the magnetic core of the main part of a permanent magnet or an electromagnet may not interrupt an optical path in order to make uniform the magnetic field of the direction which is parallel or intersects an optical path, it is not necessary to process these into a special configuration, and a Faraday-rotation child can be manufactured by the low cost.

[0074] Furthermore, the direction dependency of the demagnetizing field produced by impressing a magnetic field can be abolished by making a magneto optics crystal spherical. Therefore, since demagnetizing field do not change intensity even if the direction of an impression magnetic field changes, a more uniform magnetic field can be impressed and control of a Faraday-rotation angle can be made easy.

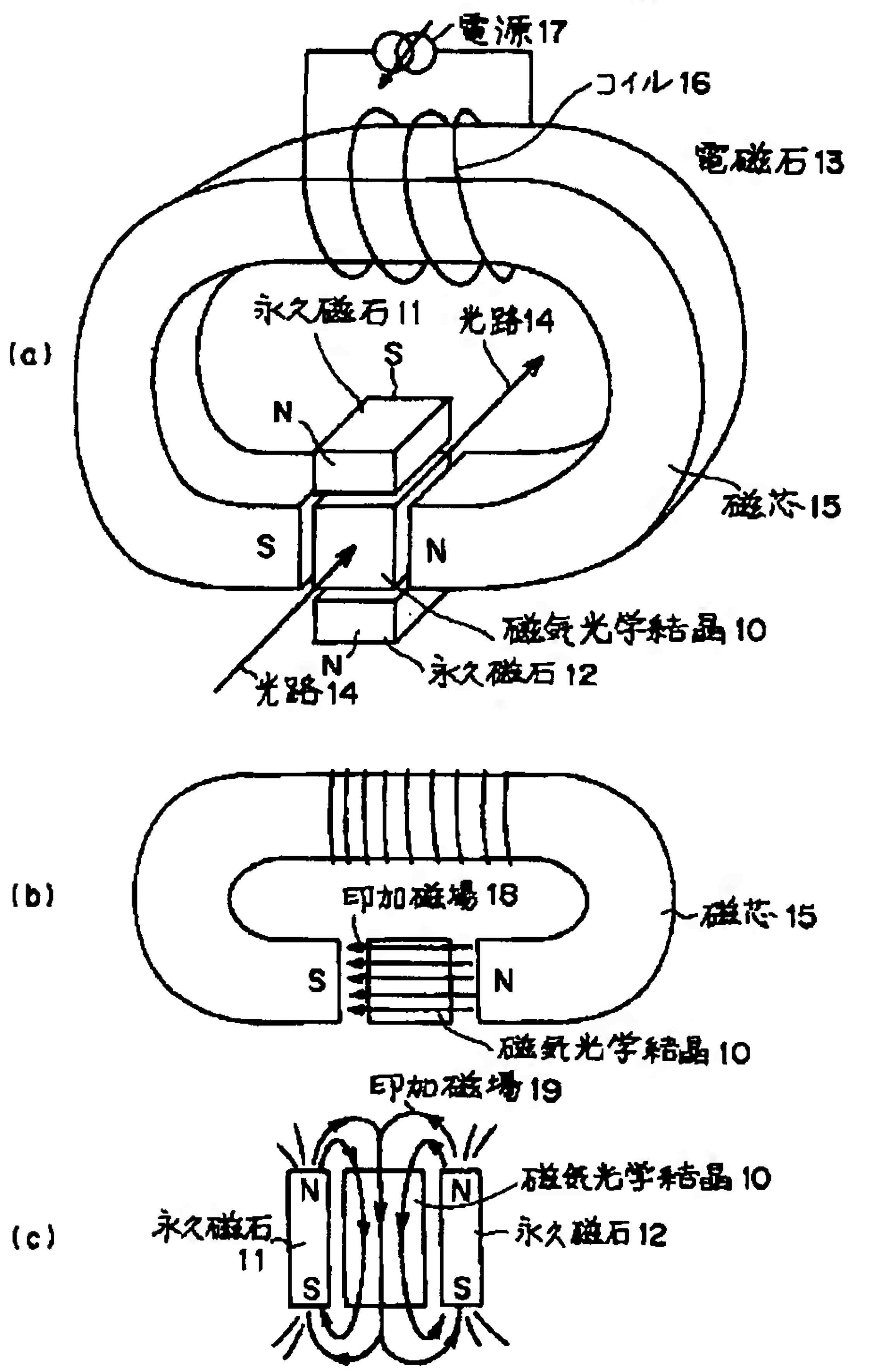
[Translation done.]

* NOTICES *

DRAWINGS

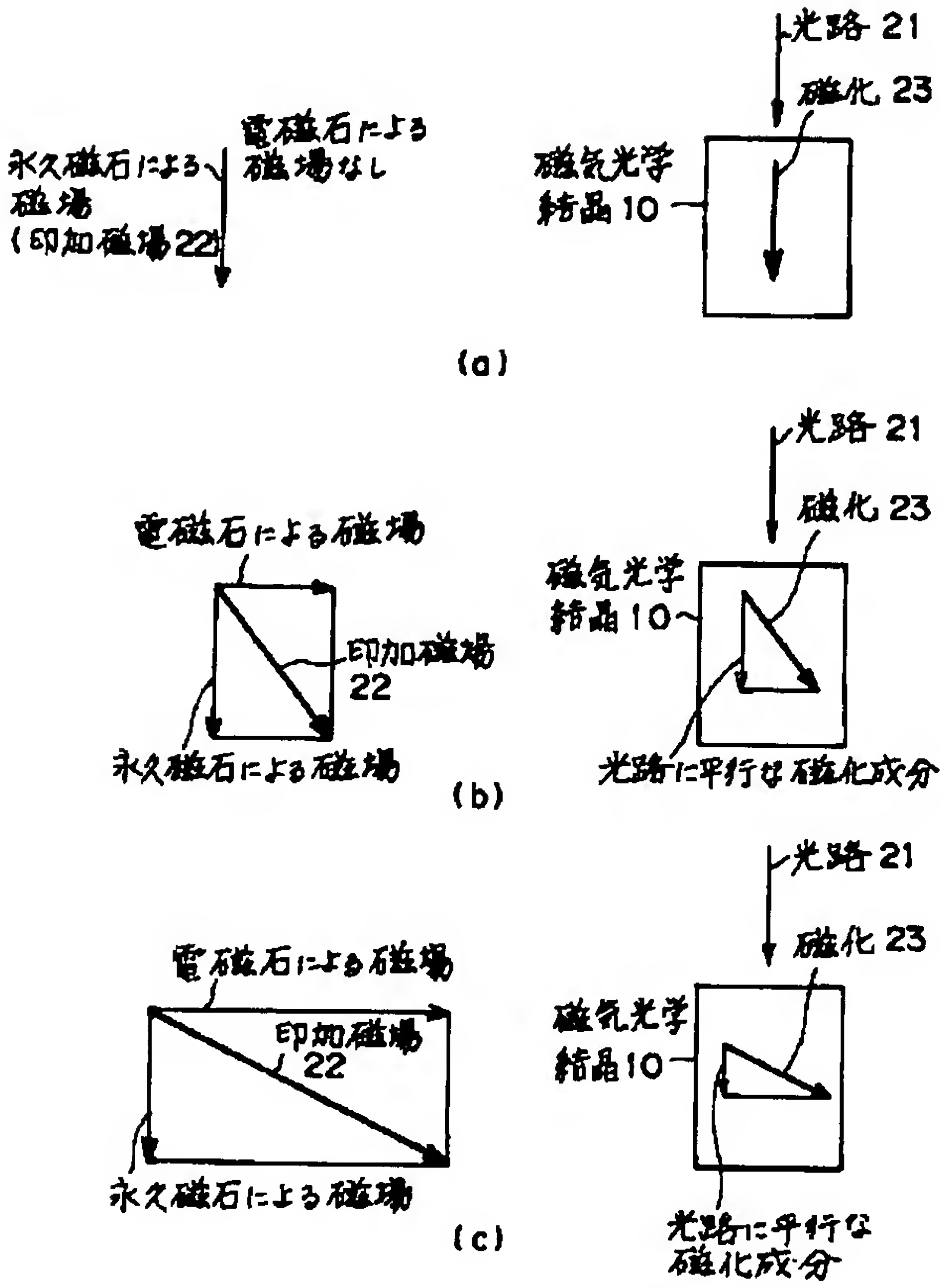
[Drawing 1]

本発明のファラデー回転子の一実施例の構成及び磁気光学結晶に印加される磁場の様子を示す図



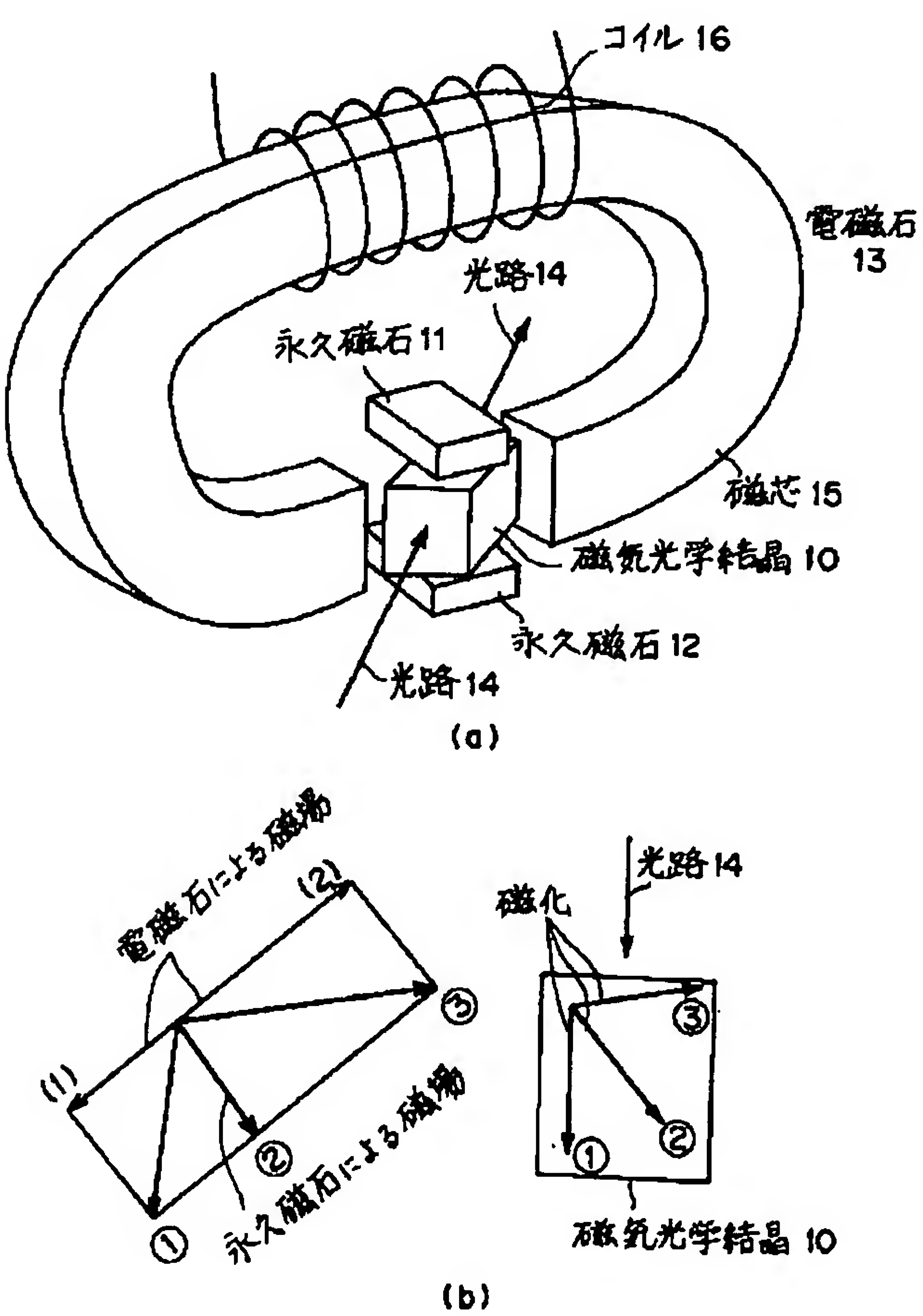
[Drawing 2]

磁気光学結晶に印加される磁場と磁化の関係を示す図

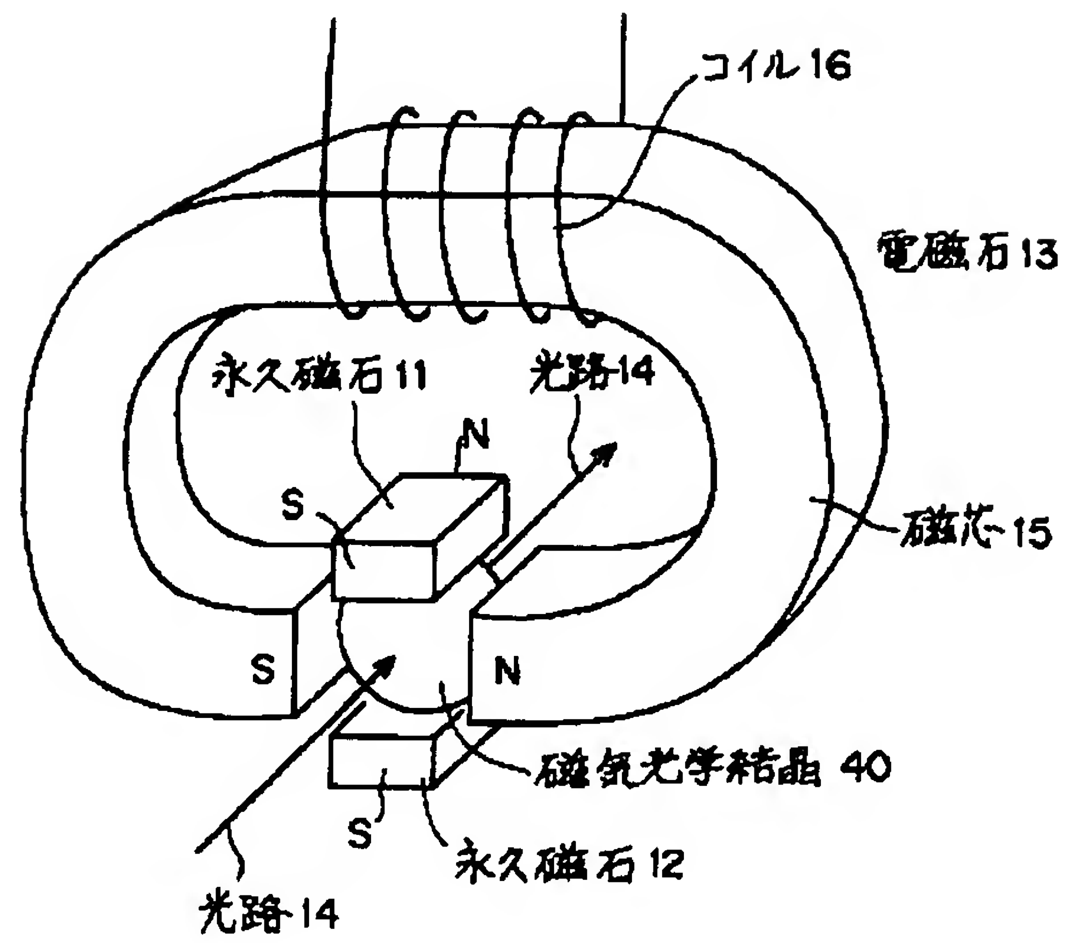


[Drawing 3]

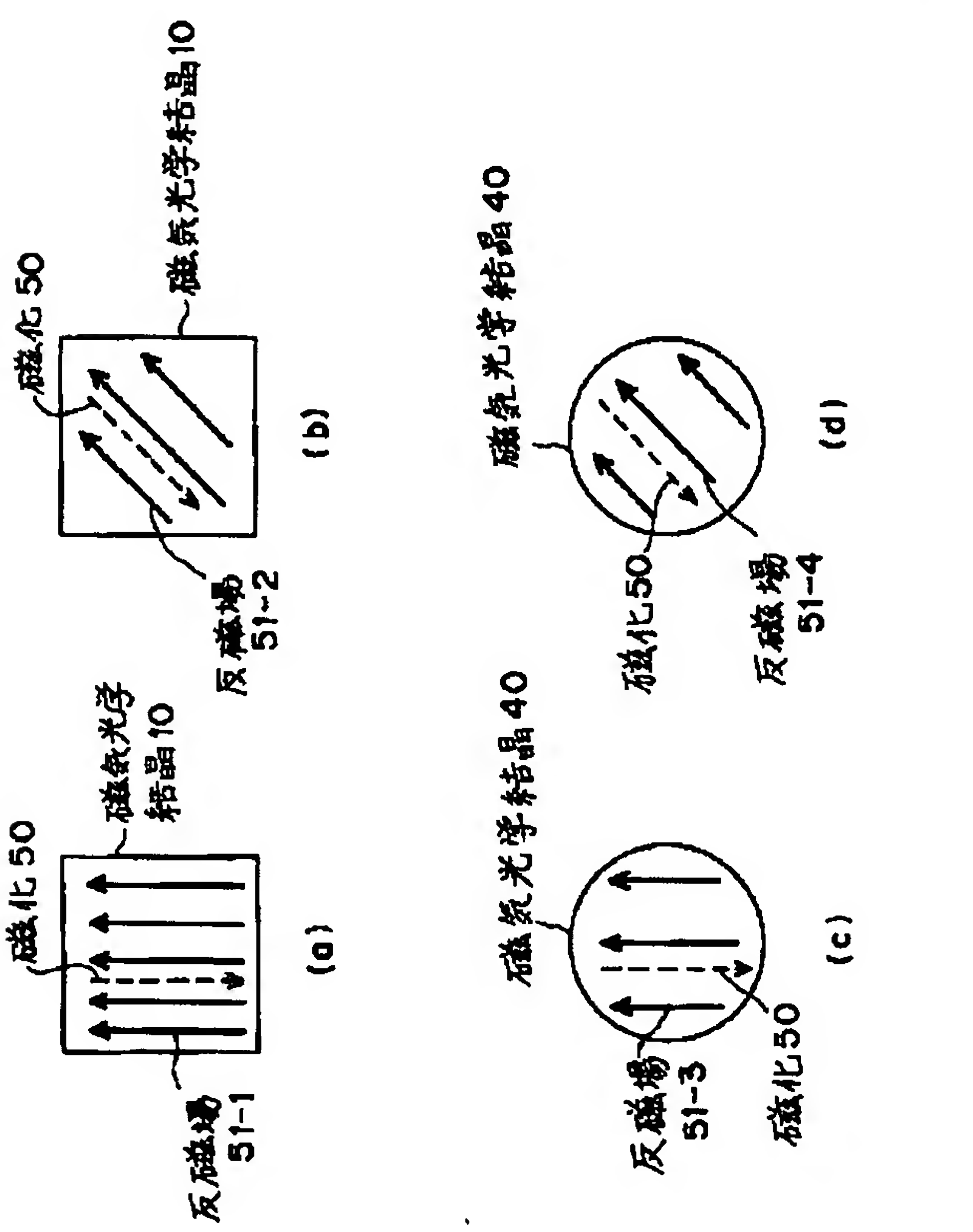
図1の実施例の一変形例及び印加磁場と磁化の関係を示す図



[Drawing 4]
本発明の他の実施例を示す図

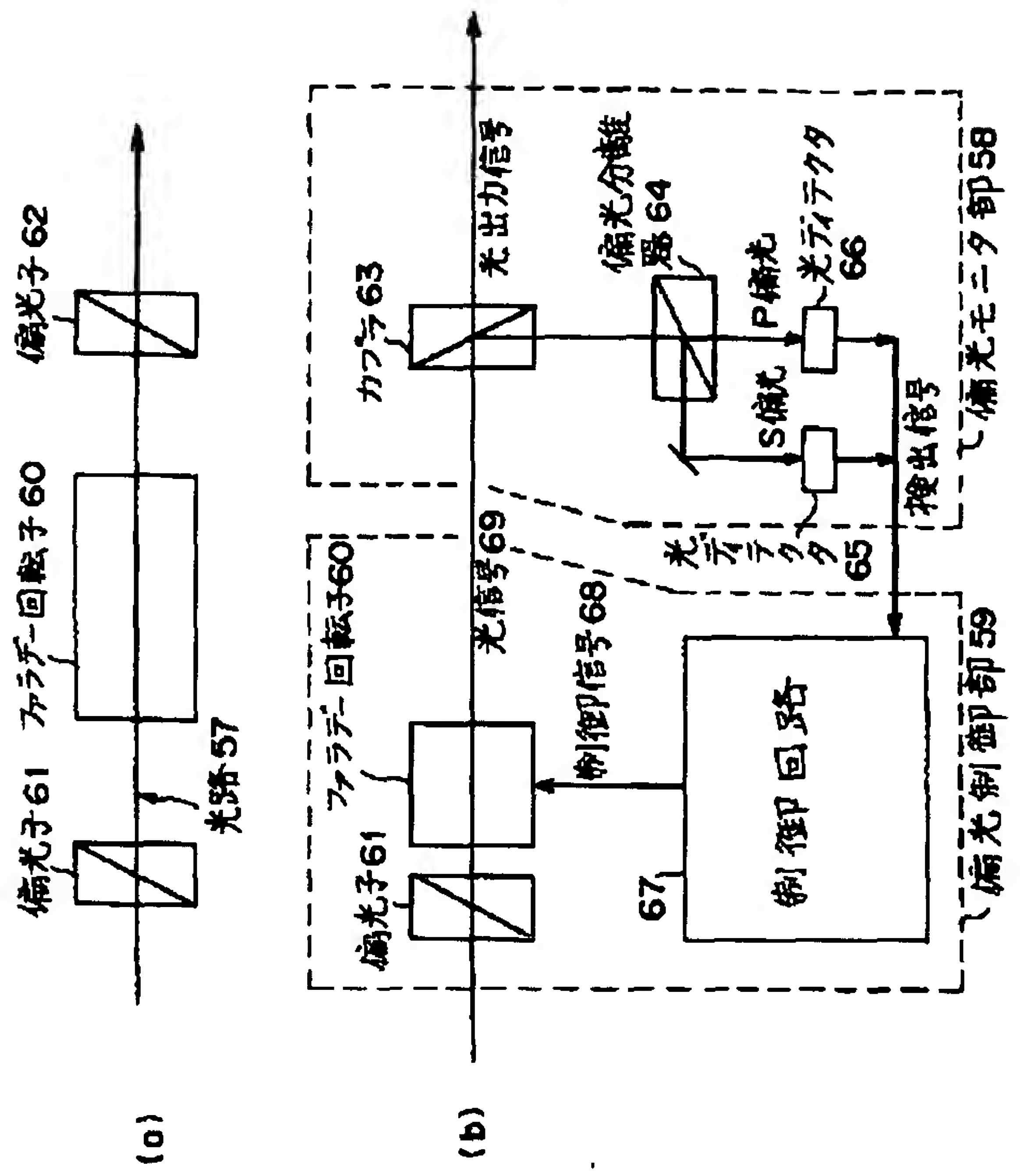


[Drawing 5]
磁気光学結晶内部に生じる反磁場の影響を説明する図



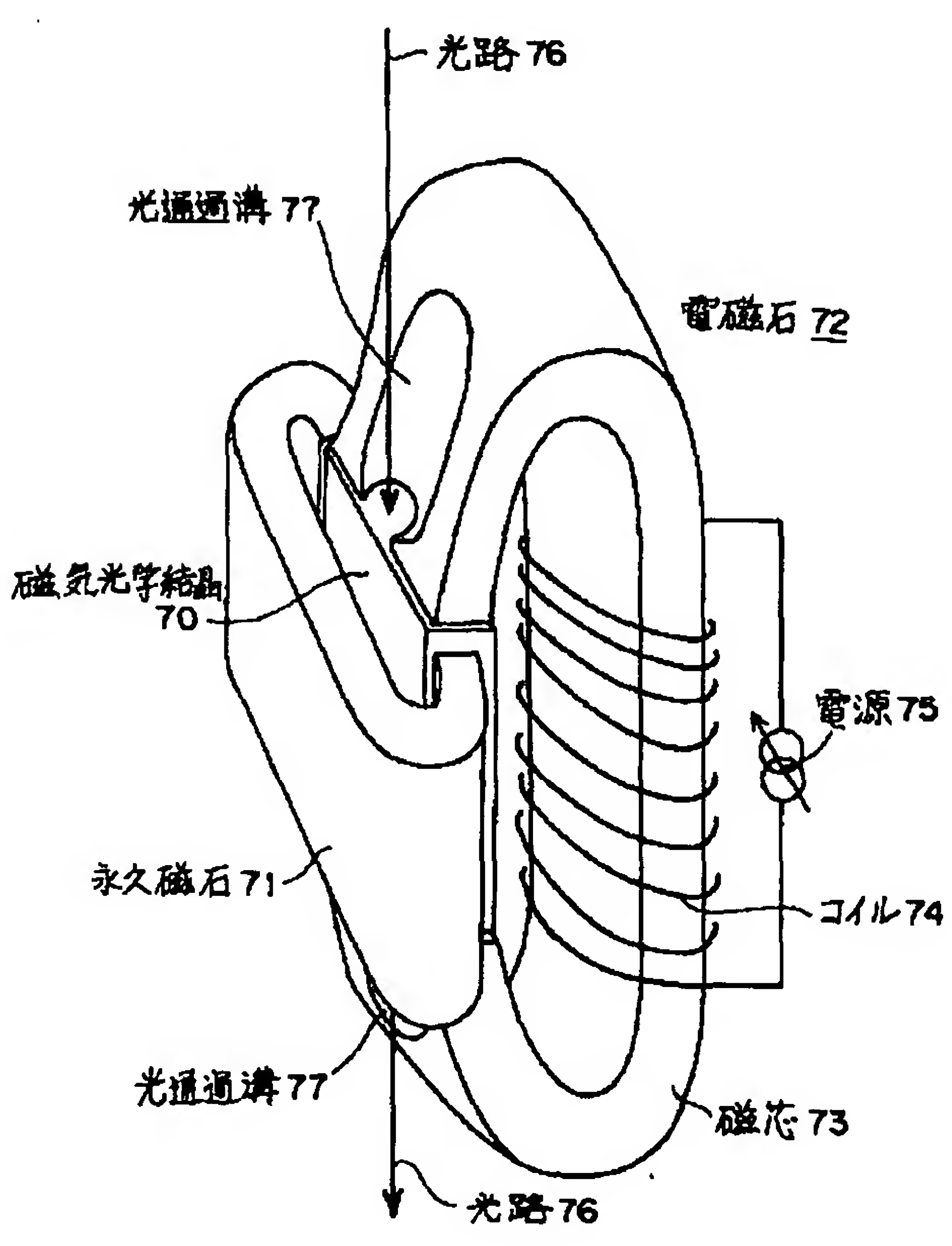
[Drawing 6]

本発明の応用例を示す図



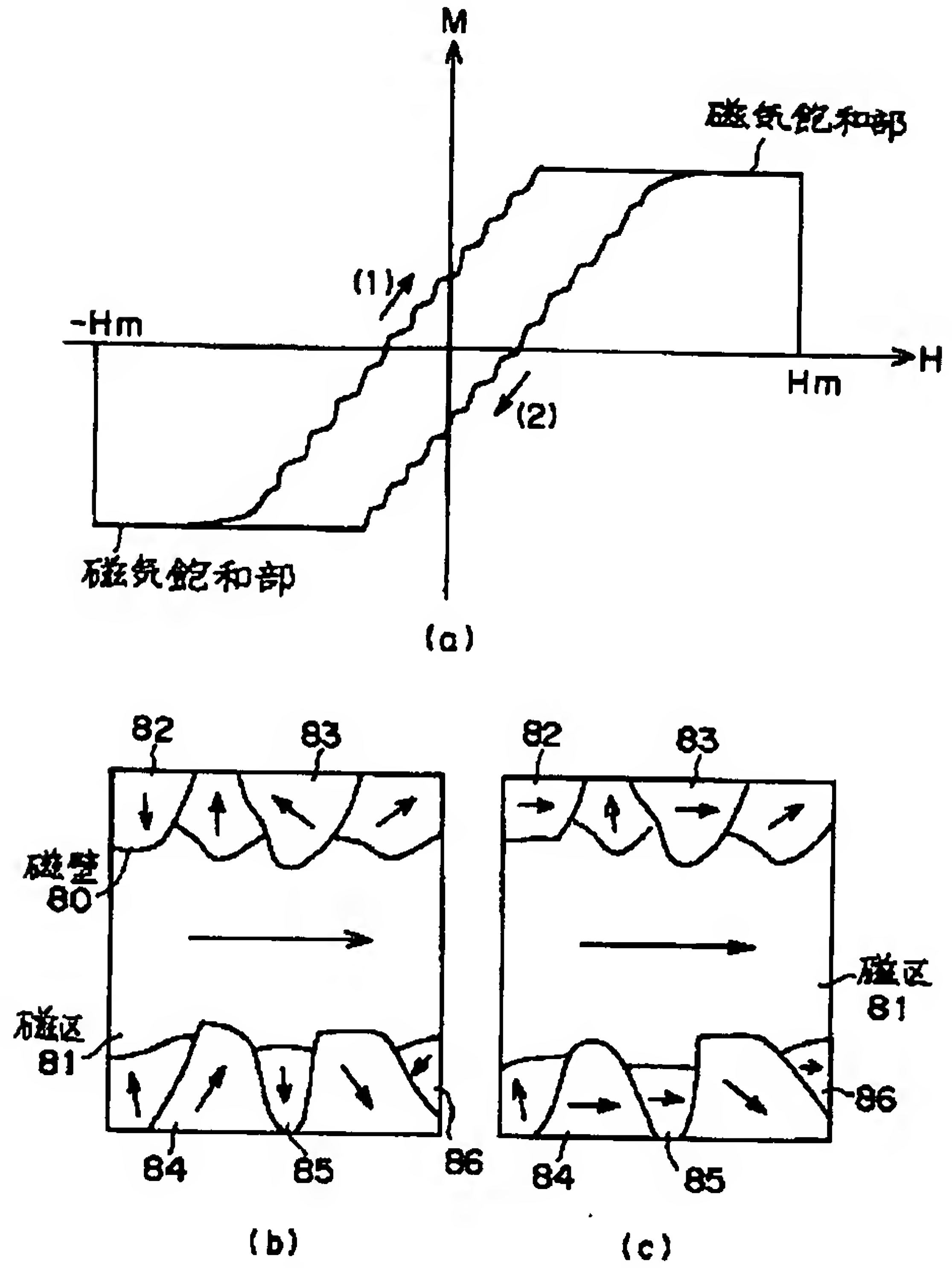
[Drawing 7]

従来のファラデー回転子の構成図

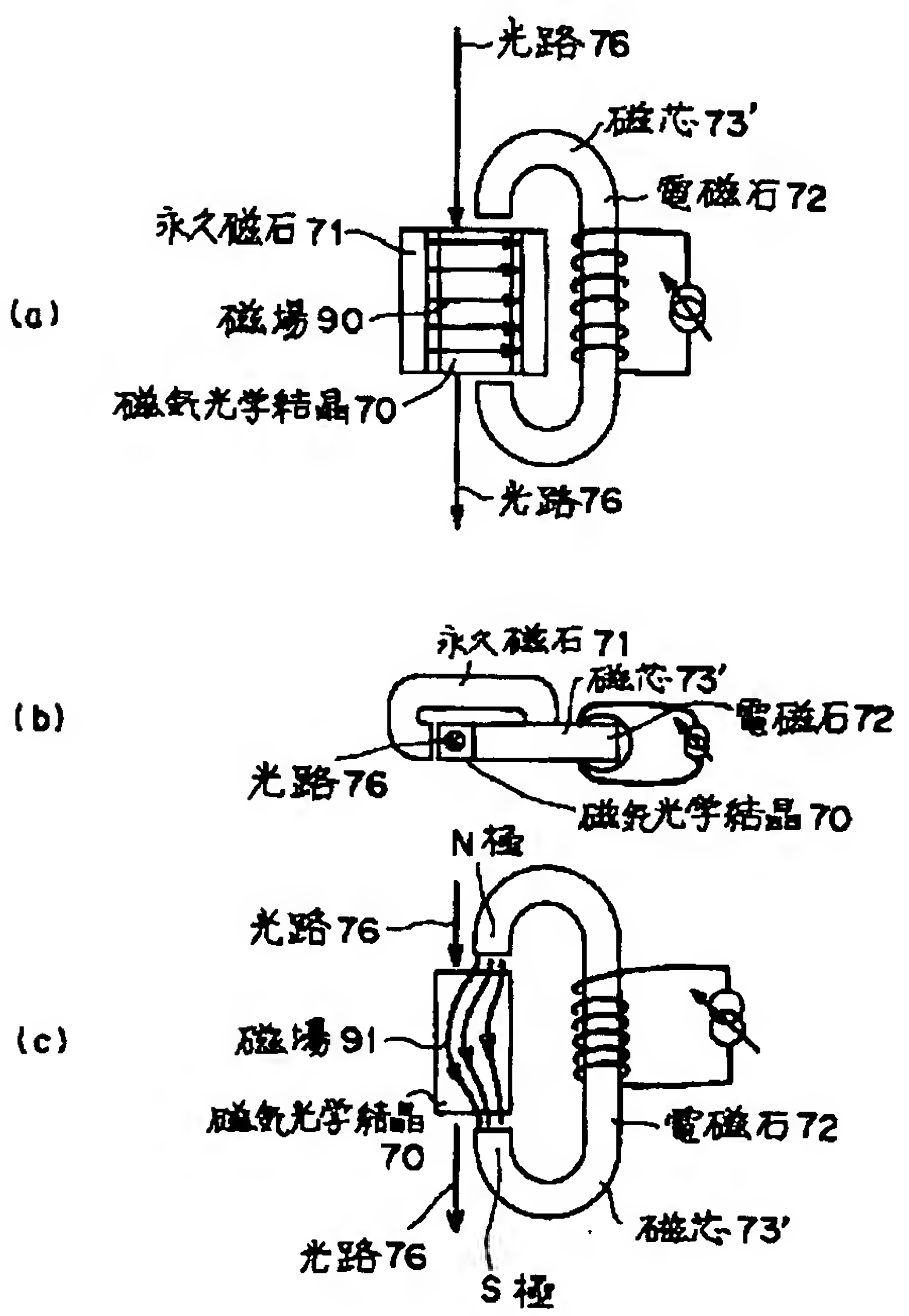


[Drawing 8]

磁化の回転とこれによる
ファラデー回転角の影響を説明するための図



[Drawing 9]
従来のファラデー回転子の問題点を説明する図



[Translation done.]

CORRECTION or AMENDMENT

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[FI]

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[Procedure revision]
[Filing Date] August 15, Heisei 14 (2002. 8.15)
[Procedure amendment 1]
[Document to be Amended] Specification.
[Item(s) to be Amended] Claim.
[Method of Amendment] Change.
[Proposed Amendment]
[Claim(s)]
[Claim 1] In the Faraday-rotation child who makes a Faraday-rotation angle adjustable by changing the magnetic field impressed to a magneto optics crystal
The permanent magnet which impresses and carries out magnetic saturation of the magnetic field of the 1st direction which is parallel or intersects the travelling direction of the aforementioned incident light arranged so that the optical path of the incident light which carries out incidence to the aforementioned magneto optics crystal may not be interrupted to the aforementioned magneto optics crystal,
The Faraday-rotation child characterized by impressing the magnetic field of the 2nd direction where it is a perpendicular or the crossing direction, and the 1st directions of the above differ in the aforementioned travelling direction of the aforementioned incident light to the aforementioned magneto optics crystal, and having the electromagnet magnetic field strength and whose direction are adjustable.
[Claim 2] The direction of the magnetic field which the aforementioned permanent magnet impresses to the aforementioned magneto optics crystal (the 1st direction of the above) is a Faraday-rotation child according to claim 1 characterized by being within the limits of zero - 45 degrees to the travelling direction of the aforementioned incident light.
[Claim 3] The direction of the magnetic field which the aforementioned electromagnet impresses to the aforementioned magneto optics crystal (the 2nd direction of the above) is a Faraday-rotation child according to claim 1 or 2 to whom it is characterized by the bird clapper within the limits of zero - 45 degrees to a direction perpendicular to the travelling direction of the aforementioned incident light.
[Claim 4] The direction of each magnetic field which the aforementioned permanent magnet and the aforementioned electromagnet impress to the aforementioned magneto optics crystal (the 1st direction of the above and the 2nd

direction of the above) is the Faraday-rotation child of any one publication of the claim 1-3 characterized by lying at right angles mutually.
[Claim 5] At least two aforementioned permanent magnets are the Faraday-rotation children of any one publication of the claim 1-4 characterized by being prepared and being mutually arranged focusing on the aforementioned magneto optics crystal at the symmetric position.
[Claim 6] At least two aforementioned permanent magnets are the Faraday-rotation children of any one publication of the claim 1-4 characterized by being prepared and being mutually arranged to the aforementioned optical path of the aforementioned incident light at the symmetric position.
[Claim 7] The configuration of the aforementioned permanent magnet is the Faraday-rotation child of any one publication of the claim 1-6 characterized by being the square pole-like.
[Claim 8] The magnetic field which the aforementioned permanent magnet impresses to the aforementioned magneto optics crystal is a Faraday-rotation child given [any / one] in the claims 1-7 characterized by being parallel to the aforementioned optical path.
[Claim 9] The magnetic field which the aforementioned electromagnet impresses to the aforementioned magneto optics crystal is the Faraday-rotation child of any one publication of the claim 1-8 characterized by the perpendicular thing to the aforementioned optical path.
[Claim 10] The configuration of the aforementioned magneto optics crystal is the Faraday-rotation child of any one publication of the claim 1-9 characterized by being a globular form.
[Claim 11] The aforementioned magneto optics crystal is the Faraday-rotation child of any one publication of the claim 1-10 characterized by being the single crystal of YIG.
[Claim 12] In the optical equipment which contains in part the Faraday-rotation child who makes a Faraday-rotation angle adjustable by changing the magnetic field impressed to a magneto optics crystal
The aforementioned Faraday-rotation child,
The permanent magnet which impresses and carries out magnetic saturation of the magnetic field of the 1st direction which is parallel or intersects the travelling direction of the aforementioned incident light arranged so that the optical path of the incident light which carries out incidence to the aforementioned magneto optics crystal may not be interrupted to the aforementioned magneto optics crystal,
Optical equipment characterized by impressing the magnetic field of the 2nd direction where it is a perpendicular or the crossing direction, and the 1st directions of the above differ in the aforementioned travelling direction of the aforementioned incident light to the aforementioned magneto optics crystal, and having the electromagnet magnetic field strength and whose direction are adjustable.
[Claim 13] In the optical attenuator containing the Faraday-rotation child who makes a Faraday-rotation angle adjustable by changing the magnetic field impressed to a magneto optics crystal, and the polarizer to which it is made to rotate by this Faraday-rotation child, and the transparency intensity of an incident light is changed according to a **** rotatory polarization angle
The aforementioned Faraday-rotation child,
The permanent magnet which impresses and carries out magnetic saturation of the magnetic field of the 1st direction which is parallel or intersects the travelling direction of the aforementioned incident light arranged so that the optical path of the incident light which carries out incidence to the aforementioned magneto optics crystal may not be interrupted to the aforementioned magneto optics crystal,
The electromagnet magnetic field strength and whose direction the magnetic field of the 2nd direction where it is a perpendicular or the crossing direction, and the 1st directions of the above differ in the aforementioned travelling direction of the aforementioned incident light is impressed to the aforementioned magneto optics crystal, and are adjustable,
The optical attenuator characterized by ************.
[Claim 14] In the optical modulator containing the Faraday-rotation child who makes a Faraday-rotation angle adjustable by changing the magnetic field impressed to a magneto optics crystal, the polarizer to which it is made to rotate by this Faraday-rotation child, and the transparency intensity of an incident light is changed according to a **** rotatory polarization angle, and the modulation control means to which the aforementioned Faraday-rotation angle is changed in dimension
The aforementioned Faraday-rotation child,
The permanent magnet which impresses and carries out magnetic saturation of the magnetic field of the 1st direction which is parallel or intersects the travelling direction of the aforementioned incident light arranged so that the optical path of the incident light which carries out incidence to the aforementioned magneto optics crystal may not be interrupted to the aforementioned magneto optics crystal,

The optical modulator characterized by impressing the magnetic field of the 2nd direction where it is a perpendicular or the crossing direction, and the 1st directions of the above differ in the aforementioned travelling direction of the aforementioned incident light to the aforementioned magneto optics crystal, and having the electromagnet magnetic field strength and whose direction are adjustable.

[Claim 15] In an optical switch including a change means to make a Faraday-rotation angle adjustable, to penetrate the light of the Faraday-rotation child who changes an incident light into the 1st polarization state and the 2nd polarization state, and the polarization state of the above 1st, and to intercept the light of the polarization state of the above 2nd by changing the magnetic field impressed to a magneto optics crystal

The aforementioned Faraday-rotation child,

The permanent magnet which impresses and carries out magnetic saturation of the magnetic field of the 1st direction which is parallel or intersects the travelling direction of the aforementioned incident light arranged so that the optical path of the incident light which carries out incidence to the aforementioned magneto optics crystal may not be interrupted to the aforementioned magneto optics crystal,

The optical switch characterized by impressing the magnetic field of the 2nd direction where it is a perpendicular or the crossing direction, and the 1st directions of the above differ in the aforementioned travelling direction of the aforementioned incident light to the aforementioned magneto optics crystal, and having the electromagnet magnetic field strength and whose direction are adjustable.

[Claim 16] The aforementioned change means is an optical switch according to claim 15 characterized by changing the travelling direction of the light of the polarization state of the above 2nd.

[Claim 17] In a polarization controller equipped with the Faraday-rotation child who makes a Faraday-rotation angle adjustable by changing the magnetic field impressed to a magneto optics crystal, a polarization monitor means to detect the polarization state of the output light from this Faraday-rotation child, and the control means which control the rotatory polarization angle of an incident light based on the polarization state detected by this polarization monitor means

The aforementioned Faraday-rotation child,

The permanent magnet which impresses and carries out magnetic saturation of the magnetic field of the 1st direction which is parallel or intersects the travelling direction of the aforementioned incident light arranged so that the optical path of the incident light which carries out incidence to the aforementioned magneto optics crystal may not be interrupted to the aforementioned magneto optics crystal,

The polarization controller characterized by impressing the magnetic field of the 2nd direction where it is a perpendicular or the crossing direction, and the 1st directions of the above differ in the aforementioned travelling direction of the aforementioned incident light to the aforementioned magneto optics crystal, and having the electromagnet magnetic field strength and whose direction are adjustable.

[Claim 18] Magneto optics crystal,

The 1st and the 2nd permanent magnet to which it is prepared, it is parallel and a magnetic field is impressed to this magneto optics crystal to the optical path of the light which carries out incidence so that this magneto optics crystal may be inserted, and magnetic saturation of this magneto optics crystal is carried out,

The Faraday-rotation child characterized by preparing the electromagnet to which a magnetic field is applied at an angle of predetermined to the optical path of this magneto optics crystal.

[Claim 19] Magneto optics crystal,

The 1st and the 2nd permanent magnet to which it is prepared and a magnetic field is impressed to this magneto optics crystal at an angle of predetermined to the optical path of the light which carries out incidence so that this magneto optics crystal may be inserted, and magnetic saturation of this magneto optics crystal is carried out,

The Faraday-rotation child characterized by having the electromagnet which impresses a magnetic field at an angle of predetermined [to the optical path of this magneto optics crystal / from the aforementioned angle of the aforementioned permanent magnet / different].

[Procedure amendment 2]

[Document to be Amended] Specification.

[Item(s) to be Amended] 0002.

[Method of Amendment] Change.

[Proposed Amendment]

[0002]

[Description of the Prior Art] A Faraday-rotation child is an element for controlling the polarization state of light using the Faraday effect that plane of polarization rotates, in case light passes through the inside of a magnetic field parallel to the travelling direction. Generally, a Faraday-rotation child consists of a magnetic field impression means for

making the magneto optics crystal which has magnetization, and this magneto optics crystal produce magnetization, and rotates the plane of polarization of light by passing light inside the magneto optics crystal which magnetization produced. The angle which plane of polarization rotated is called Faraday-rotation angle by having passed the magneto optics crystal.

[Translation done.]